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Value of scintigraphy in chronic peritoneal dialysis patients

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Background. A variety of factors can adversely impact chronic peritoneal dialysis (CPD) as an effective renal replacement therapy for patients with end-stage renal disease. These factors include peritonitis, poor clearances, loss of ultrafiltration, and a variety of anatomic problems, such as hernias, peritoneal fluid leaks, loculations, and catheter-related problems caused by omental blockage. This study reviews our experience with peritoneal scintigraphy for the evaluation of some of these difficulties.

Methods. From 1991 to 1996, 50 peritoneal scintigraphy scans were obtained in 48 CPD patients. Indications for scintigraphy were evaluated, and the patients were placed into four groups: group I, abdominal wall swelling; group II, inguinal or genital swelling; group III, pleural fluid; and group IV, poor drainage and/or poor ultrafiltration. A peritoneal scintigraphy protocol was established and the radiotracer isotope that was used was 2.0 mCi of ^{99m}technetium sulfur colloid placed in two liters of 2.5% dextrose peritoneal dialysis solution.

Results. Ten scans were obtained to study abdominal wall swelling, with seven scans demonstrating leaks; six of these episodes improved with low-volume exchanges. Twenty scans were obtained to evaluate inguinal or genital swelling, and 10 of these had scintigraphic evidence for an inguinal hernia leak (9 of these were surgically corrected). One of four scans obtained to evaluate a pleural fluid collection demonstrated a peritoneal-pleural leak that corrected with a temporary discontinuation of CPD. Sixteen scans were obtained to assess poor drainage and/or ultrafiltration. Five of these scans demonstrated peritoneal location, and all of these patients required transfer to hemodialysis. The other 11 scans were normal; four patients underwent omentectomies, allowing three patients to continue with CPD.

Conclusion. Peritoneal scintigraphy is useful in the evaluation and assessment of CPD patients who develop anatomical problems (such as anterior abdominal, pleural-peritoneal, inguinal, and genital leaks) and problems with ultrafiltration and/or drainage.

Key words: abdominal wall, pleural fluid, ultrafiltration, omentum, loculation.

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There has been a continued increase in the number of end-stage renal disease patients maintained on chronic peritoneal dialysis (CPD). Many patients choose CPD as their preferred chronic dialysis treatment, but approximately 20% of patients "drop out" and transfer to hemodialysis annually [1]. Although peritonitis remains the major cause of transfer to hemodialysis, other factors such as exit-site infections, catheter-related problems, hernias, loss of ultrafiltration, and poor clearances contribute to CPD technique failure [1]. Considerable effort and research has been directed at trying to determine, diagnose, and treat these causes of technique failure in order to permit the continuation of long-term therapy with CPD.

Routine laboratory evaluation or physical examination can detect some CPD-related complications. Other patients require more sophisticated studies to evaluate their problems properly. Over the past several years, we have developed experience with peritoneal scintigraphy to assess problems involving the peritoneal dialysis cavity for CPD patients. This article relates our experience with this technique over a five-year period.

METHODS

New Haven CAPD is a freestanding peritoneal dialysis center. The overall function and operation of the facility have been previously described [2]. From 1991 to 1996, 50 peritoneal scintigraphy scans were done in 48 patients. During this time, we treated a mean of 204 patients with CPD per year. The scintigraphic studies were retrospectively reviewed for clinical indications, scintigraphic findings, and the correlation with clinical outcome.

The clinical indications for peritoneal scintigraphy were grouped into four categories: group I, abdominal wall swelling with a possible diagnosis of umbilical or incisional hernia or pericatheter leak of peritoneal dialysis solution; group II, inguinal or genital swelling; group III, pleural fluid with a possible diagnosis of a pleuroperitoneal leak; group IV, poor catheter drainage or ultrafiltration defined by prolonged drainage times, intermittent problems with drainage, and/or impaired ul-

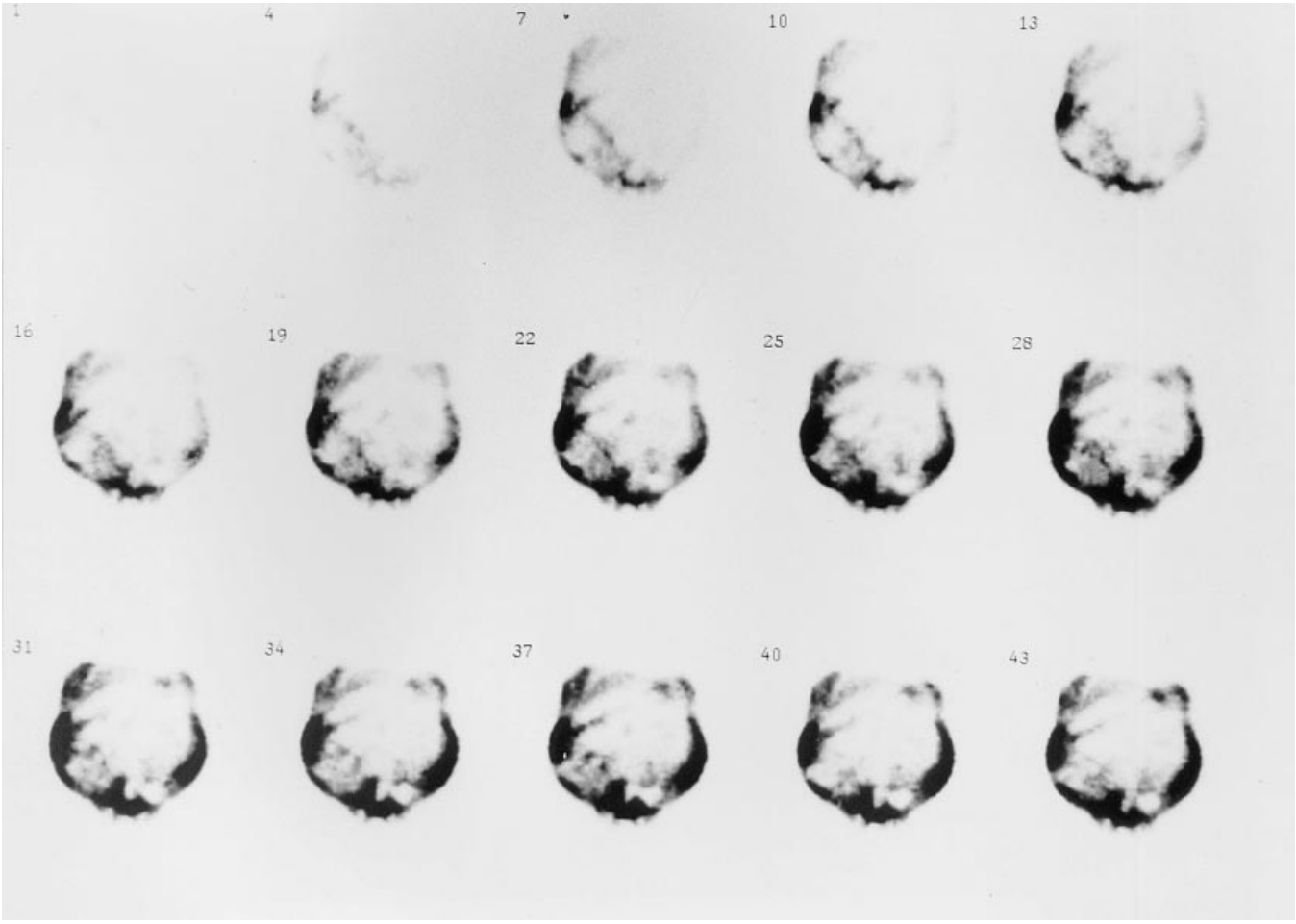


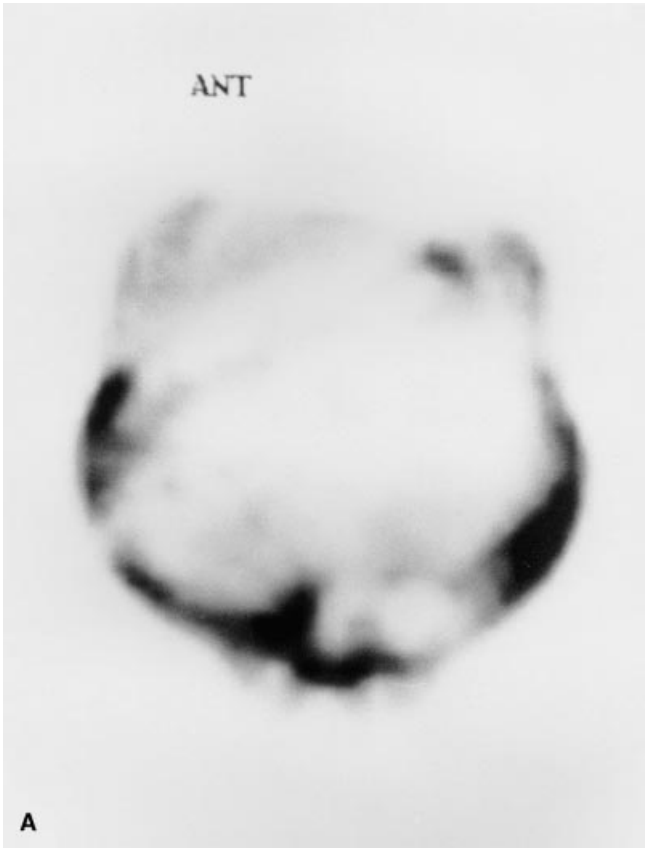
Fig. 1. Normal peritoneal scintigraphy scan. Instillation phase images. Free movement of dialysate infusate with radiotracer into paracolic, subdiaphragmatic and pelvic gutters.

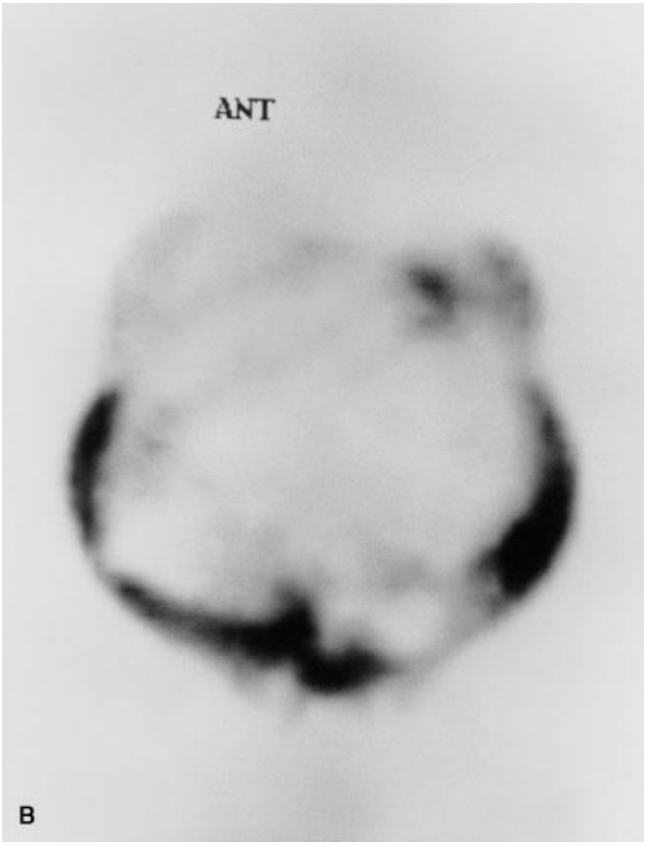
trafiltration not attributable to high peritoneal transport characteristics as determined by the peritoneal equilibration test that Twardowski et al standardized [3].

Prior to the scintigraphic study, the abdominal cavity was drained of all dialysis solution in the nuclear medicine department. After complete drainage, the patient was placed supine under the gamma camera to allow a full view of the abdomen and the lung bases. A dual detector gamma camera (Trionix, Tweensberg, OH, USA) was used to image the peritoneal cavity for computer acquisition images. The scintigraphic study was performed by mixing 2.0 mCi of ^{99m}technetium sulfur colloid in two liters of 2.5% dextrose peritoneal solution (Dianeal®) and then rapidly infusing the dialysate. During the instillation phase, dynamic infusion images were obtained at one frame per minute for 15 minutes (Fig. 1). Immediately after the infusion was completed, postinfusion images (5 min per view) were obtained in the anterior, posterior, lateral, and oblique projections (Fig. 2A). The patient then walked for 10 to 15 minutes. Nonambulatory patients were asked to roll side to side while on the imaging table to promote the intraperitoneal mixing of the radiotracer. A second set of spot images in the anterior, posterior, lateral, and oblique projections (postambulatory images) was then acquired (Fig. 2B). The peritoneal cavity was drained, and a third set of postdrain images was obtained (Fig. 2C). A normal scan should demonstrate free flow of dialysate fluid throughout the peritoneal cavity outlining the intraperitoneal recesses, absence of extraperitoneal dialysate tracking into the anterior abdominal wall, pericatheter, pleural cavity, inguinal, canal or genital area, and limited residual tracer activity after fluid drainage. Scans were obtained in some patients after 24 hours if the clinical suspicion was high that a hernia or dialysate leak was present and if the initial scan was considered normal.

RESULTS

Forty-eight patients had 50 peritoneal scintigraphy scans between 1991 and 1996. Patients studied included





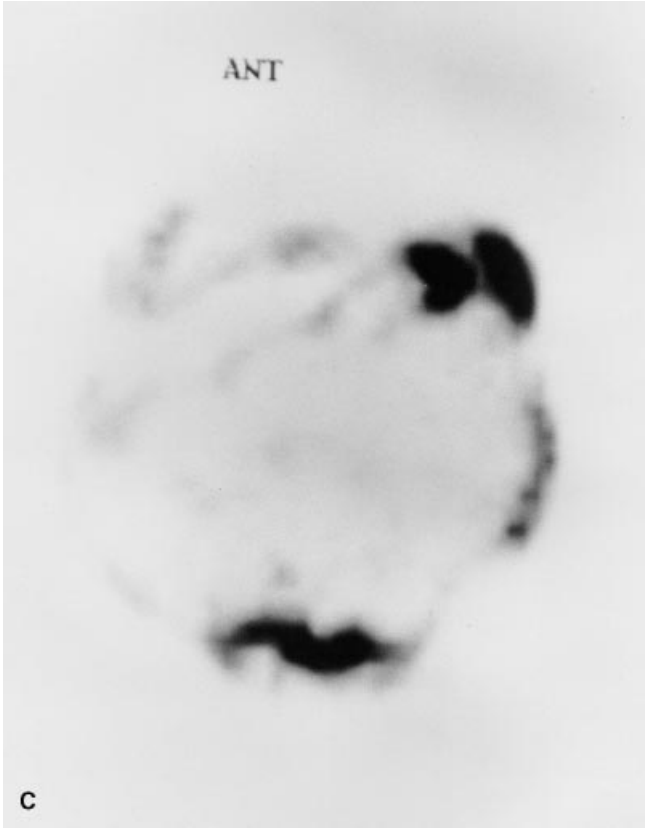
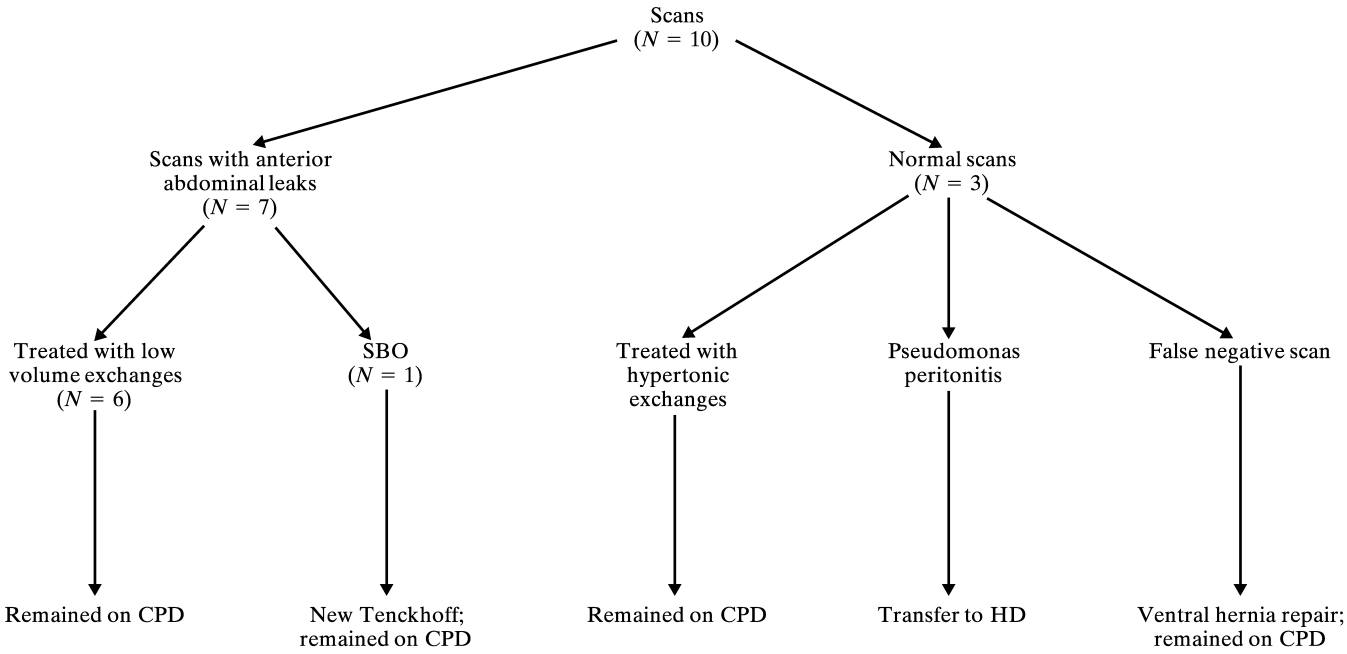


Fig. 2. Normal postinfusion, ambulatory, and drain images. (*A*) Post-infusion image showing the anterior abdomen with normal intraperitoneal distribution of radiotracer. (*B*) Post-ambulatory image with an anterior view that is similar to the post-infusion phase in normal cases. (*C*) Post-drain image showing an anterior abdominal view with residual activity in splenic fossa. The left paracolic and pelvic regions are significantly less than the post-infusion images.

Table 1. Group I (abdominal wall swelling)



27 males and 21 females with a mean ± SD age of 60 ± 15.3 years (range of 24 to 90 years). The patients had been maintained on CPD for 23.8 ± 29.8 months prior to their scans with a range of 1 to 132 months.

Group I

In seven of the 10 scans in Group 1 (abdominal wall swelling in 8 patients), radiotracer was identified tracking into the anterior abdominal wall (Table 1). An example of a scan demonstrating a leak of dialysate into the anterior abdominal wall is shown in Figure 3. Six of these seven scans were treated successfully with low-volume (1.0 liter) exchanges or temporary discontinuation of peritoneal dialysis. One patient developed small bowel obstruction and was treated with temporary hemodialysis. A new Tenckhoff catheter was subsequently placed, and the patient successfully resumed CPD therapy.

Three scans were normal, and the clinical diagnosis of fluid overload causing anterior abdominal swelling was made. Hypertonic dialysis exchanges and increased ultrafiltration resulted in successful resolution of the swelling in one patient. A second patient developed Pseudomonas peritonitis three days after the scan, thus requiring the removal of the Tenckhoff catheter and transfer to hemodialysis. The third patient was treated with hypertonic exchanges without improvement. Because of persistent anterior wall edema, surgical exploration was undertaken, which revealed a small ventral hernia. After hernia repair, the patient was able to continue with CPD. It is noteworthy that a 24-hour scan was not obtained in this patient.

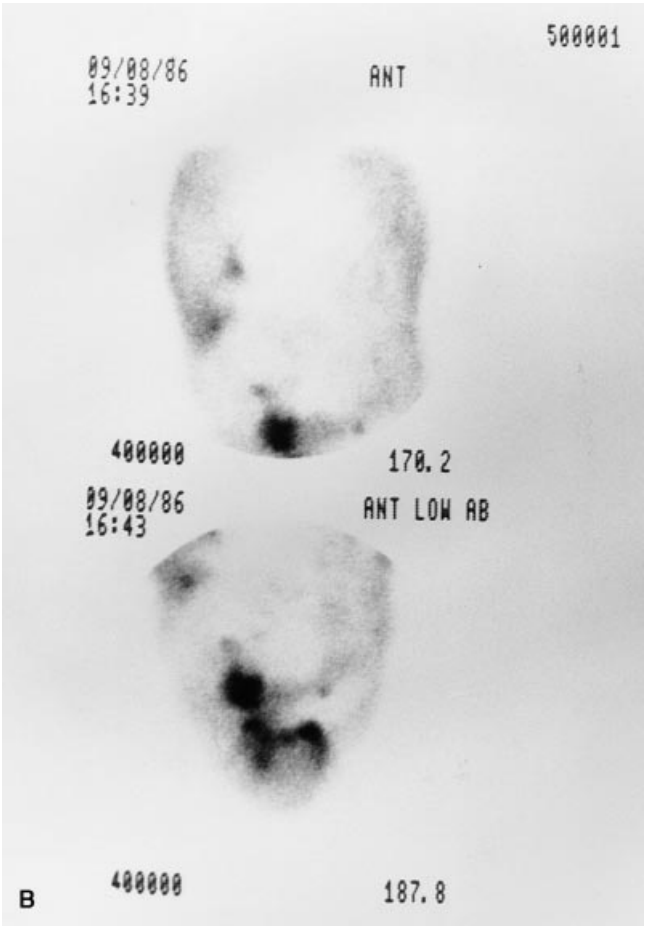
Group II

Peritoneal scintigraphy demonstrated the presence of an inguinal hernia leak in 10 scans in Group II patients (inguinal or genital swelling in 20 patients, 20 scans; Fig. 4 and Table 2). Nine of these patients had successful repair of the inguinal hernia with resumption of peritoneal dialysis and resolution of the edema. The site of the hernia was correctly identified in nine scans. In one of the nine patients, a second clinically inapparent hernia was identified by the scan in the opposite inguinal region and was corrected at the time of surgery. The tenth patient expired with a myocardial infarction prior to surgical repair of the inguinal hernia detected on the scintigraphy scan.

The 10 remaining scans were normal, with free flow of dialysate fluid throughout the peritoneal cavity and the absence of fluid tracking into the inguinal canal and genital area. The genital and inguinal edema resolved following aggressive ultrafiltration with hypertonic peritoneal dialysis solution in 8 of these 10 patients. In one patient, the inguinal swelling persisted despite ultrafiltration. Surgical exploration was eventually performed with the repair of a small hernia. The patient was then able to continue with CPD. The 10th patient chose to discontinue peritoneal dialysis five days after the scan.

Group III

One scan revealed a pleural-peritoneal leak in Group III patients (pleural fluid found in four patients, four



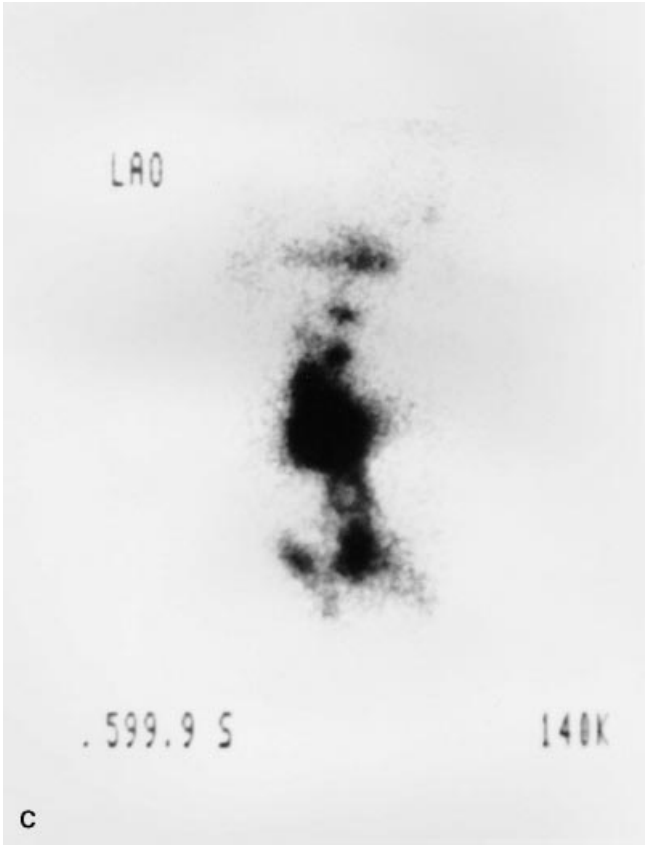


Fig. 3. Anterior abdominal leak. (*A*) The postinfusion image demonstrates normal intraperitoneal distribution of radiotracer. (*B*) The postambulation images demonstrate extravasation of fluid and collection in midline abdominal wall region. (*C*) A 24-hour delayed scan of left anterior oblique projection. At 24 hours, the full extent of the leakage can be appreciated in the anterior abdominal wall.

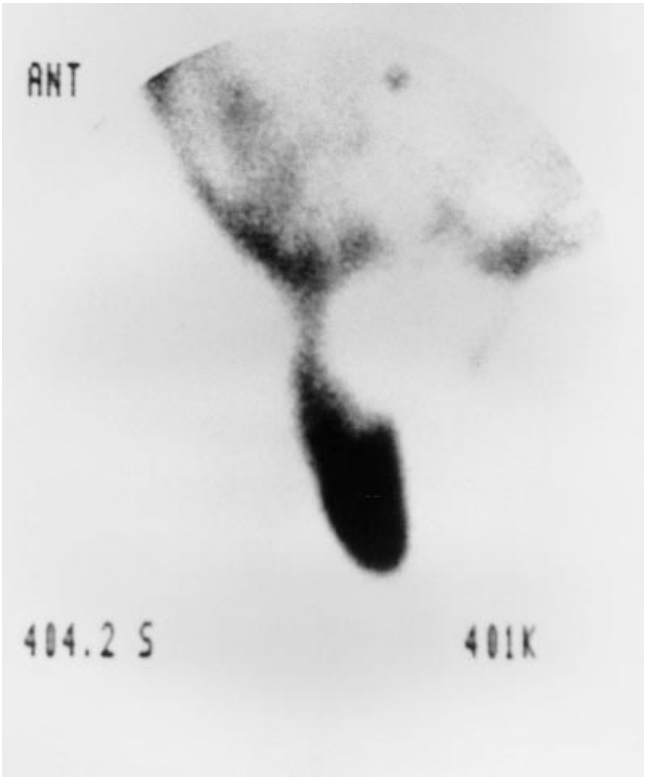


Fig. 4. Inguinal scrotal hernia. The postinfusion images outline the right inguino-scrotal fluid collection. There is also demonstration of a left inguinal hernia.

scans). This patient was temporarily transferred to hemodialysis. The effusion resolved, and the patient returned to CPD without recurrence of the pleural effusion.

The remaining three scans were normal. These three patients had evidence of volume overload, and the pleural effusion resolved following aggressive dialysis ultrafiltration. These patients successfully continued CPD therapy.

Group IV

Five scans demonstrated loculated fluid collections within the abdominal cavity of Group IV patients (poor drainage/poor ultrafiltration in 16 patients, 16 scans; Fig. 5 and Table 3). These patients all had a prior history of CPD-associated peritonitis. Manipulation of the dialysis regimen did not improve the ultrafiltration and drainage problems, and these patients were transferred to hemodialysis.

Eleven scans were normal. In this group with normal scans, two patients had measured weekly urea kinetics $< 1.5/1.73\ m^2$ and were transferred to hemodialysis. Four patients had spontaneous resolution of the problem. The five remaining patients had intermittent episodes of incomplete and prolonged drainage. Four of these five patients underwent omentectomy for possible intermittent omental obstruction of the catheter. Three patients who underwent omentectomies were able to continue with CPD. The fourth patient who had an omentectomy did not improve and was transferred to hemodialysis. The fifth patient had a new Tenckhoff catheter placed. A surgical decision was made not to perform an omentectomy, and the patient successfully continued with CPD.

DISCUSSION

Many peritoneal dialysis patients suffer CPD technique failure and are forced to transfer to hemodialysis. Identification of the problem that is causing technique failure is important if CPD is to be a viable long-term therapy. Peritonitis, catheter exit-site infections, and psychosocial stress are frequent causes of CPD dropout [1]. Other problems that are sometimes more difficult to evaluate and treat include membrane transport problems (such as small surface area, rapid transport characteristics, and high lymphatic flow) [4] and anatomical problems including leaks, hernias, omental obstruction, adhesions, and loculated areas in the peritoneal cavity.

Imaging of the peritoneal cavity to identify and define anatomic problems in CPD patients has been reported with scintigraphy and computed tomography (CT) peritoneography. CT peritoneography has the capability to define clearly the peritoneal cavity [5], but it does require the use of intraperitoneal contrast and, in most patients, the additional use of oral or intravenous contrast. Peritoneal scintigraphy has the added advantage of determining if the free flow of fluid within the peritoneal cavity is present. We have established a peritoneal scintigraphy protocol and found this radiological evaluation useful for the assessment of dialysate leaks, hernias, problems with drainage, and loss of ultrafiltration. This protocol involves the use of 2.0 mCi of ^{99m}technetium sulfur colloid mixed with two liters of 2.5% CPD solution. Images are obtained with a dual-detector gamma camera during the infusion, dwell, postambulatory, and postdrain phases. Infusion phase images are obtained every minute for 15 minutes. Anterior, posterior, lateral, and oblique images are obtained after infusion, postambulation or movement, and following drainage of dialysis solution. In selected patients, 24-hour postdrain images are obtained.

We categorized patients into four groups based on their presenting signs and symptoms. The groups were abdominal wall swelling, inguinal or genital swelling, pleural fluid and poor drain or ultrafiltration.

Abdominal wall swelling

Reports of anterior abdominal wall pathology in CPD patients are numerous. Problems that have been described include leaks and ventral and incisional hernias (in some cases incarcerated or strangulated hernias), with a reported incidence of 5 to 31% of CPD patients [6–10]. Risk factors that may predispose patients to these

Table 2. Group II (inguinal or genital swelling)

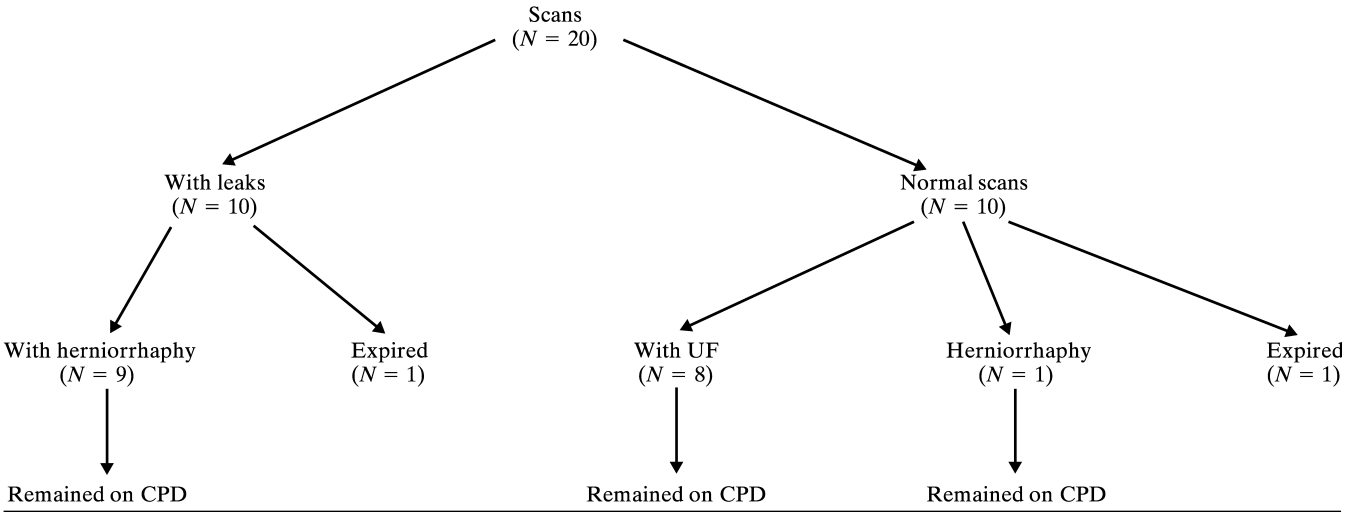
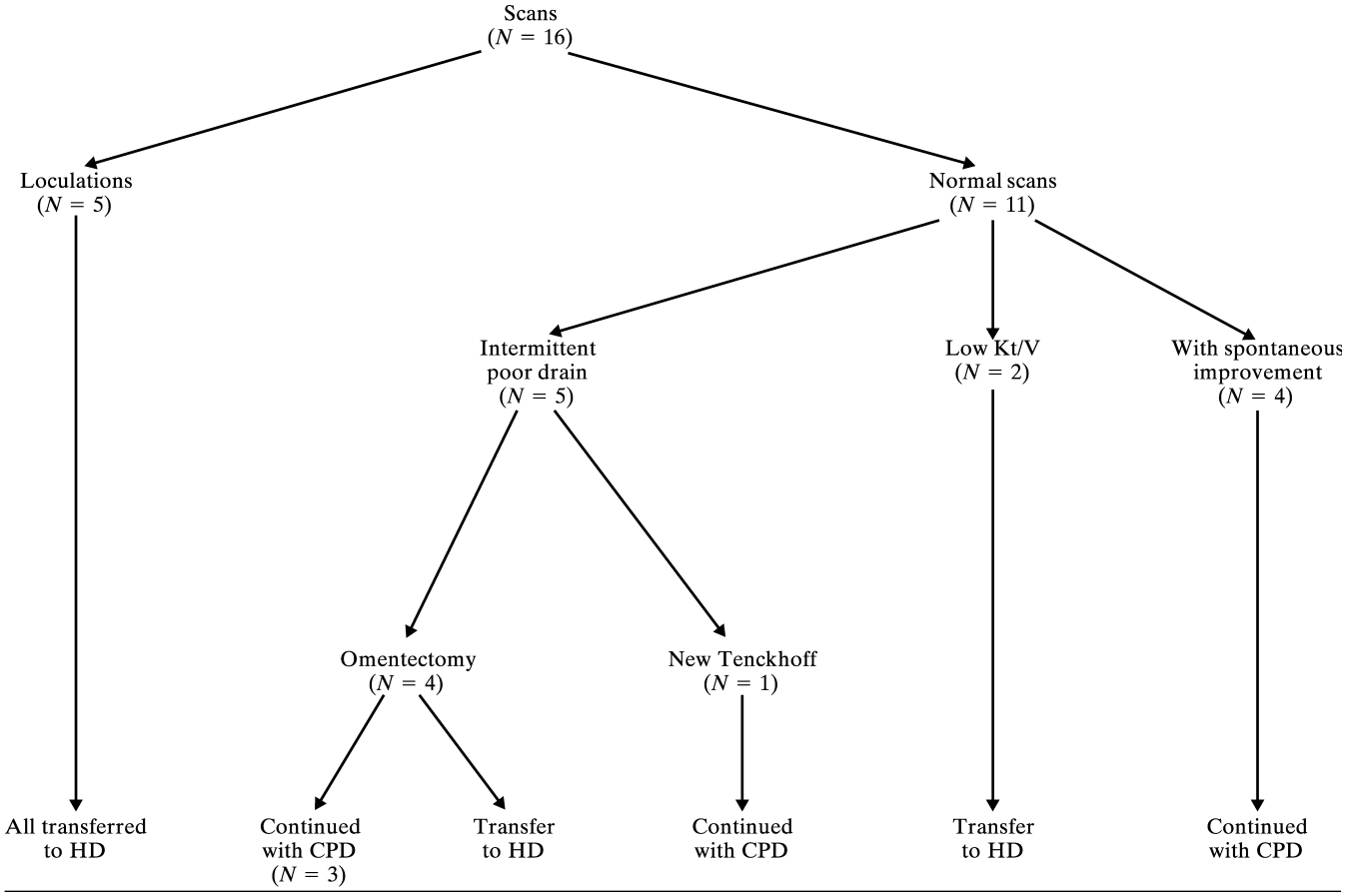


Fig. 5. Loculated fluid. The post-infusion image demonstrated loculated intraperitoneal fluid. The radiotracer is confined to the left paracolic and pelvic area.

Table 3. Group IV (poor drainage/poor ultrafiltration)



complications include a history of previous abdominal surgery, an age of greater than 60, steroid use, obesity, early use of the dialysis catheter, trauma, and failure of proper cuff placement [9]. Winchester and Kriger suggest that the pericatheter leaks be treated by withholding CPD for two to four weeks until the leak seals [9]. Tzamaloukas et al reported that early leaks can be treated successfully with temporary discontinuation of CPD [10]. In our study, six of seven episodes of anterior abdominal leaks were successfully managed by the use of low-volume exchanges or the temporary discontinuation of CPD.

Goh et al noted pericatheter and incisional swelling in nine patients [8]. Scintigraphy scan correctly identified seven of nine leaks. There was one false negative and one true negative scan in a patient whose swelling improved with ultrafiltration. One of our patients with anterior abdominal swelling had a false negative scan, and a hernia was noted at the time of surgery. This patient did not have a 24-hour scan, which we have subsequently found to be useful for the identification of slow anterior abdominal dialysate leaks that are not visualized on the initial scan.

Inguinal or genital swelling

Some patients on CPD may present with evidence of inguinal and genital edema. There have been several reports in the literature commenting on the use of peritoneal scintigraphy in CPD patients to help diagnose inguinal leaks [6, 7]. Goh et al found that scintigraphy correctly identified 10 hernias in 10 suspect cases [8]. In our series, we evaluated 20 patients with genital swelling. In those 20 patients in which an inguinal leak was suspected, 10 had scintigraphic evidence for an inguinal hernia, and 10 had normal studies. Of those patients with normal scans, 8 of 10 improved with aggressive ultrafiltration. One patient discontinued CPD several days after the scan was obtained. The 10th patient had eventual surgical exploration for persistent inguinal swelling, and a small hernia was noted. The scans were clearly useful in separating those patients with a leak that required surgical repair from those patients with normal scans, where increased ultrafiltration resolved the edema. One of the patients had the added benefit of surgical repair of a clinically unsuspected second hernia that was discovered at time of peritoneal scintigraphy.

Pleural fluid

Peritoneal-pleural leaks have also been reported. In a recent editorial review by Ramon and Carrasco, the reported prevalence of hydrothorax in CPD patients was 1.6 to 10.0% [11]. In our five-year review, we suspected pleural leaks in only four patients. A peritoneal-pleural leak was confirmed by scintigraphy in only one case. The pleural fluid in the other three cases resolved with aggressive ultrafiltration.

Poor drainage and/or poor ultrafiltration

The use of scintigraphy for the evaluation of poor dialysate effluent drainage or poor ultrafiltration has not been previously reported. Anatomical etiologies for poor drainage or ultrafiltration include blockage of the Tenckhoff catheter by part of the omentum and peritoneal adhesions that may cause loculated areas within the peritoneal cavity and impair dialysate flow.

We report 16 patients with 16 scans that were obtained for prolonged or intermittent poor drainage and impaired ultrafiltration. Impaired ultrafiltration by high peritoneal transport characteristics was excluded in these patients by peritoneal equilibration test determinations [3]. The scintigraphy scan diagnosed five patients with intraperitoneal loculations, and all did poorly on CPD, requiring transfer to hemodialysis. The loculations were likely due to peritoneal adhesions from prior peritonitis, reducing the effective peritoneal surface area and thereby requiring discontinuation of peritoneal dialysis. Hollett et al described seven patients with loculations and five cases of adhesions diagnosed with CT peritoneography [5].

The majority of patients with normal distribution of dialysis solution continued CPD (7 of 11). Some patients with normal dialysate distribution by scintigraphy scan may have poor dialysis efflux because of omental occlusion of the dialysis catheter. A history of intermittent poor drainage and poor ultrafiltration would seem to suggest that omentum may be occasionally obstructing the catheter and interrupting dialysate flow. Lewis et al reported 10 episodes of omental obstruction in 44 patients, but they did not describe how these patients were identified [12]. Prischl et al described four patients with drainage difficulties [13]. Omental obstruction was believed to be present from radiocontrast study, but the specific radiographic abnormalities that allowed this diagnosis were not described. Several investigators have commented on the indications for omentectomies in CPD patients. The indications have included omentectomies to improve catheter function in those patients that present with omental catheter obstruction [11] and partial omentectomies at the time of catheter insertion to enhance catheter survival [12]. Four of our patients in fact underwent omentectomies, and three of them were able to continue with CPD.

In conclusion, peritoneal scintigraphy is a useful tool to evaluate various problems that may present in CPD patients. Scintigraphy is particularly helpful in identifying patients who present with inguinal or scrotal swelling caused by hernia leaks and who would benefit from surgical intervention. Scintigraphy may be of value in the identification of those patients with pleural-peritoneal leaks and anterior abdominal wall leaks. Among patients with poor dialysis effluent drainage and/or impaired ultrafiltration, the scintigraphic finding may help clarify the etiology and direct intervention.

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